International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 5, Issue 1, Feb 2015, 1-10

RESIDUAL STRESS PRODUCED AFTER MACHINING IN MECHANICAL COMPONENTS AND ITS EFFECTS ON FATIGUE LIFE: A STATE OF ART

D. S. MANKAR[1] & P. M. KHODAKE[2]

[1]Research Student, Government College of Engineering, Amravati, Maharashtra, India

[2]Principal, Government College of Engineering, Karad, Maharashtra, India

ABSTRACT

The residual stresses are produced during metal working of engineering components before they are exposed to the service. This phenomenon is dominant in machining processes where cutting tool and work material are in contact with each other and as a result of elastic-plastic deformation of the material, heat treatment. Such stresses are found to have a very significant effect on the fatigue lifeof components. Those stresses that exist in a machine part without external loading being present, these residual stresses are “locked into” the component in the absenceof external loadingand represent a datum stress over which the service load stresses are subsequently superimposed. An exhaustive research is necessary to measure and control such stresses so that corrective measures can be taken while designing the components for expected service. This paper presents an exhaustive literature on the development of residual stresses in machining processes in general and turning operation in particular.

KEYWORDS: Residual Stresses, Fatigue Life, Surface Integrity, Fatigue Performance, Fatigue Crack Growth, Etc

INTRODUCTION

The residual stresses play an important role in fatigue life of engineering components. All engineering components before being subjected to service loading conditions contain stresses owing to the history of the material prior to such service. The stresses produced during elastic-plastic deformation in mechanical working of the material, heat treatment, chemical treatment, joining procedure etc., are termed residual stresses [1].These stresses may vary in depth, magnitude and sign. Such stresses are usually produced while manufacturing parts and can have a very significant effect on the fatigue life of components [2].

Residual stress can be tensile or compressive and the stressed layer can have multiple depths, depending upon the cutting conditions, work material, cutting tool geometry and contact conditions at the tool/chip and tool/work piece interfaces [3]. As shown in figure 1, the compressive residual stress close to the surface of the work piece is high and decreases as the depth increases. At certain depth the residual stress becomes negligible and further increase in the depth results into tensile residual stress. Compressive residual stresses generally improve component performance and life because they promote service stresses and prevent crack nucleation. On the other hand, tensile residual stresses tend to increase service stresses which lead to premature failure of components [3].

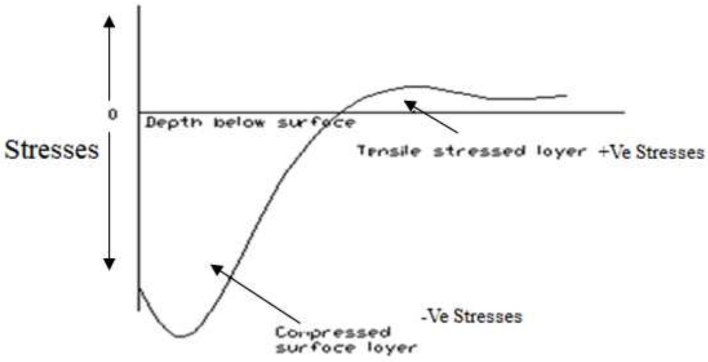

Figure 1: Residual Stresses Distribution along the Depth of Surface [3]

The literature on the effect of residual stresses on the performance of components is available under different keywords like residual stress, machining parameters, surface integrity, fatigue life, fatigue, machining, manufacturing processes, fatigue performance, fatigue crack growth, etc. The literature available on different machining processes is collated together and presented in six different sections.

- Development of residual stresses
- Mathematical and simulation models
- Experimentation carried out
- Measurement techniques
- Other machining processes

DEVELOPMENT OF RESIDUAL STRESSES

Residual stresses generally arise when conditions in the outer layer of a material differ from those internally. The most significant mechanical processes which induce surface residual stresses are those which involve plastic yielding. Practically all standard machining processes such as grinding, turning, polishing etc. involve local yielding and hence induce residual stresses [4]. It has been observed that plastic deformation is almost invariably present in any machining process.The extent of the plastically deformed layer, and hence the residually stressed region will depend on the depth of cut, sharpness of tool, rates of speed and feed, and the machinability of the material.

Two distinct kinds of residual stresses i. e. macrostresses and microstresses exist with an inherent difference between them. Macrostresses are those residual stresses which are in equilibrium within macrodomains, covering volumes comparable in size to the part; they concur with the concept of isotropic material. Microstresses are crystal within single metal grain or group of grains in equilibrium within volumes comparable with dimensions of the grains. These include submicroscopic stresses which relate to distortion in atomic lattices of crystals [1].

Macostresses have been widely investigated, including the reasons for their occurrences and how they affect the strength and other properties of metal. Normally the macrostresses are listed in technical specifications of parts and are inspected in surface layers after manufacturing [2]. Macrostresses, in general, are either tension stresses or compressive stresses. Residual tension stresses are detrimental, since they reduce fatigue strength and impair wear and corrosion resistance of machine parts. Compression stresses, to the contrary, are believed to be beneficial. In the manufacture of

machine parts the residual stresses are grouped accordingly to the shape and trajectory of the processing tool: tangential, in the displacement; and radial, perpendicular to the processed surface [1]. The creation of residual stresses is caused by elastic-plastic deformation, which takes place in the contact area between the tool and workpiece and is sometimes by high temperatures.

There are number of factors attributed to the origin of residual stresses. Under the action of the tool on the processed metal surface in machining process, three domains are formed in the surface layer: plastically deformed metal, elastically deformed metal, and unaltered initial state [1]. The plastically deformed metal has lower density and therefore higher specific volume. The internal layer prevents the increase of volume of plastically deformed metal resulting in residual compression stress in the outer layer and tension stresses in inner layers [1]. As tool moves along the processed surface, it stretches crystalline grains of surface layer, subjects to elastic and plastic tension deformation. This process is aided by friction of the tool on the processed surface. After the tool leaves the surface, the plastically stretched layer, bonded to inner layers, acquires compression stresses. Accordingly, the inner layers develop residual tension stresses for counterbalancing. The heat released in the processing area instantly heats a thin surface layer to a high temperature, increasing the specific volume. On termination on tool action a rapid cooling of the surface layer takes place causing a compression. The high pressure and temperature during deformation cause structural phase transformation in the surface layer. This is accompanied by a change in volume. When the specific volume of surface layer increases, residual compression stresses develop. When the specific volume decreases, residual tension stresses appear.These residual stresses may affect dramatically the performance of the machined part causing its premature failure or excessive wear.

MATHEMATICAL AND SIMULATION MODELS

The mathematical models for measurement of fatigue life and determination of residual stress beneath suggested by different investigators are presented in table 1.

Difference authors studied effects of residual stresses on fatigue life of components either through mathematical model or simulation models. The purpose of developing these models has been different. They are either to measure the constant, or predict characteristics of residual stresses, or to evolve relation between turning parameters and residual stresses, or to measure penetration forces.

Table 1: Mathematical and Simulation

Author	Mathematical and Simulation Model	Findings &Remarks
T.D.Marusich and E.Askari [4]	Simulation model for turning, Metal cutting operation for thermo-mechanical properties, cutter geometry and process parameters.	Studied machining simulation software AdvantEdge, which integrates advanced finite element numeric and material modeling appropriate for machining to indicate the magnitude and sign of the state of stress
Meng Liu et.al. [9]	$\sigma_{max} = r_i - \sqrt{ri \sin[\cos - 1(\frac{ri-a}{ri})] - f)\text{^}2 + (ri-a)\text{^}2}$ $l_c = r_i[\cos^{-1}(\frac{ri-a}{ri}) + \sin^{-1}(f/2r_i)]$ $k_{ref} = \tan^{-1}[\frac{\sqrt{ri-(\frac{f}{2})2-(ri-a)}}{\sqrt{ri-(ri-a)2+f/2}}]$ Where, k_{ref} is reference cutting edge angle, F_c is cutting force, F_f is feed force, F_P thrust force, r_i nose radius, l_c is arc length of machine region.	To determine the residual stress beneath the machined surface, an electro-polishing technique is utilized, and the electro-polished depth from machined surface is over 200 µm. The value of constant is measured.

Y.B. Guo and David W. Yen [10]	Simulation model using finite element analysis for residual stresses considered roller radius, number of passes for turning and grinding.	Prepared simulation model using finite element analysis for residual stress by considering roller radius, number of passes, distance per pass, rotation speed, friction speed, friction coefficient and displacement etc. This simulation applies to both elastic and plastic deformations in rolling contact.
Edoardo Capello [14]	$\sigma_r = 1000 \log (k_1 f^{k2} r^{k3}) - k_4 \chi$ Where, σ_r is axial residual stress, k_1,…. is estimated regression coefficient , f feed rate, χ is entrance angle, r is nose radius of tool.	Presented regression analysis for evolving relation between turning parameters and residual stresses.
G.F. Batalha et.al. [18]	$F_z = 6.96 + 317.35 f + 375.73 p + 2515.42 f p$ $\sigma = - 630.54 - 2172.50 a + 2128.33 p + 7600 a p$ Where, F_z is penetration force, f is feed rate, p is cutting depth.	Studied experimental model for force and stresses & measured values of the penetration forces.
Youngsik Choi [27]	$N = \frac{1}{\Delta\tau \max - 2\tau k} + \int_{d1}^{d2} \frac{\frac{1}{CHb}}{Hl} (\Delta k) n da$ Where N is the fatigue life in number of loading cycle, $\Delta\tau_{max}$ is the range of maximum shear stress, τk is the friction stress, Δk is the stress intensity factor range and n is the slope index, H_b and H_l are the knoop hardness number at bulk material and the local knop hardness number respectively .	Presented mathematical model for fatigue life through the rolling contact fatigue test. The results showed that the predicted accuracy of this model can be enhanced significantly by incorporating residual stresses and its influence on the rolling contact fatigue life by more than 40 %.
Y.B.Guo [31]	$\overset{\circ}{\dot{\sigma}} = \dot{\sigma} - w^e \sigma + \sigma w^e = \lambda \operatorname{tr} (D^e) 1 + 2\mu D^e$ Where, D is ploughed depth, Simulation model of thermo-mechanical based hybrid modeling for depth and residual stress, edge radius, chamfer angle, cutting speed.	Presented mathematical model supported by simulation and experimentation, for residual stress profiles in cutting/tangential direction to predict characteristics of residual stress profile. The predicted characteristics of residual stress profile favorably agree with the measured ones.
S. Anurag et.al .[34]	Simulation model for turning and grinding, The residual stresses profiles were predicted for a series of plowed depths potentially encountered in machining.	Studied simulation in machining tool advances in the workpiece in cutting direction to form the chip, it exerts tremendous pressure on work material in cutting direction as well as a significant amount of thrust in the downward direction. It is a thermal-mechanical based hybrid FEA modeling
C. Maranhao and J.P. Davim [41]	Simulation model using finite element analysis for residual stresses considered during machining materials with special emphasis steel.	Prepared simulation model on case study for residual stresses in machining of SS AISI 316 using FEM analysis. Cutting parameters such as a feed rate as well as rake angle are simulated to evaluate residual stresses. Residual stress mechanism is found to be influenced by process parameters.

Therefore, the relationship between residual stresses and fatigue lifecannot be clearly established. Even though the preliminary mechanism of development of residual stresses is available, the literature does not indicate the cause for its effect on fatigue life mathematically.

EXPERIMENTATION

Table 2 presents experimentation carried out by various investigators indicatingexperimentation process adopted, work materials used, machining parameters considered and the findings.

Table 2: Experimentation

Author	Experimentation and Findings	Remark
El-Axir[7]	*1-Turning, *2-Stainless Steel-304, Steel-37, 7001, 2024-Aluminum Alloy, and brass. *3-Tensile strength, cutting speed and feed *4-Residual stress continued to decrease across the section; become either tensile or compressive at large depths. Cutting speed $x_{1=}$ 2(log V-log V_{+1}) / log V_{+1}-logV_{-1}+1 Feed rate X_2 = 2(log F-log F_{+1}) / log F_{+1}-logF_{-1} + 1 Tensile strengthX_3 = 2(log T-log T_{+1} /logT_{+1}-logT_{-1} + 1 σ surface e = 18.425 + 0.769v +5014f + 26.2m+ 3.125vf+ 24.3 vm+ 13.125fm Where V, F and T are cutting speed, feed and tensile Strength of the material, respectively.	The parameters like depth of cut, tool geometry, tool material and cutting oil not studied. Presented comprehensive experimental model which has the capability of predicting residual stress profile.
Edoaedo [14]	*1-Turning,*2-Fe370 C45,39 Ni Cr Mo3 Steel,*3-side relief angle, rake angle, cutting velocity, *4-surface residual stresses in axial direction can be tensile or compressive depending on process parameters and on the characteristics of the machined material. A material with higher mechanical properties will present larger residual stresses.	tensile or compressive stresses depending on process parameters
Edoaedo [15]	*1-Turning, *2-carbon and alloy steel, *3-feed rate, nose radius, *4-The increment in residual stresses due to an increment in process parameters does not seem to be influenced by the machined material.	parameters does not influence by the machined material.
Meng Liu[9]	*1-Turning. *2-Bearing steel JIS-SUJ2,*3-Nose radius, depth of cut *4-The effects of the nose radius on the residual stress distribution decreases greatly with the increase of the tool wear.	Measured cutting forces, to determine the residual stresses beneath the machined surface. Electro-polishing technique is utilized for acquiring required depth.
Hiroyuki [12]	*1-Turning, *2-0.45% C steel, *3-Nose radius of the tool and feed rate were varied and two kinds of tool edges.*4-Higher fatigue life to the machined components comparing with the vergin material if compressive residual stress and high hardness within surface layer can be induced by cutting process.	Cutting speed, cutting force, coolants are not studied.
Ataollah Javidi [21]	*1-Hard Turning, *2- Steel 34CrNiM06, *3- Cutting Speed, Feed, Nose radius, *4-higher compressive residual stress causes a higher fatigue life and the effect of residual stress on fatigue life is more than the effect of surface roughness.	-----
Outeiro [25]	*1-Turning, *2-Inconel 718, Austenitic stainless steel AISI 316L with coated and uncoated tools. *4- Higher surface residual stresses are generated when machining with the uncoated tool than the coated tool.	------
Guo and Warren[26]	*1-Hard Turning and Grinding, *2-Stel AISI 52100,*3-Cutting velocity, feed, depth of cut for turning and grinding, grinding wheel, wheel sped, table speed, cross feed, down feed, coolant. *4- magnitude of residual stress generated by hard turning is more than 3 times larger than grinding and depth is nearly 2 times deep.	Studied the hook shaped Residual stress profile of a turned surface.

Youngsik Choi [27]	*1-Turning, *2-Steel AISI 1053, *3-Cutting speed, Nose radius, feed, depth of cut, and coolant type. *4- Residual stress could increase the rolling contact fatigue life by around 12 times.	Not considered machining parameters.
Tadeusz Leppert & Ru Lin Peng [28]	*1-Turning,*2-C-45 Steel,*3-Rake angle, clearance angle, cutting edge angle, cutting inclination angle, corner radius.*4-residual stresses depend on the applied feed rate.	Parameters related to cutting tool are considered to study influence on residual stresses in circumferential and axial direction
G.H. Farrahi et.al.[29]	$f_{km} = \sum_{q=1}^{N} w\ efkpf\ fmq$, $T_k = \sum_{q=1}^{N} w\ efkpTq$ Where, N is the number of measurement point and M number of truncated series used to approximate the residual stress field.	Studied analytical model for estimating residual tress in turning operation for determination of the stress.
Y.B. Guo [31]	*1-Turning,*2-AISI 25100 steel, *4-The depth is the most important deterministic factor for the characteristics of residual stresses in hard turning.	-----
Smaga and Eifler [33]	*1-Turning, *2-aluminium matrix composite, *3-cutting speed, feed. *4-The residual stress, where developed during the turning process, were reduced at about 50% due to initial plastic deformation up to 10 % life time.	Tool nose radius, cutting force, coolant etc are not studied.
Kortabarria [38]	*1-Turning,*2-Inconel718,*3-work 50 mm diameter round bar,40 m/min cutting speed,0.25mm depth of cut,*4-The cutting parameter the residual stresses field on the surface and subsurface layers is quite homogeneous.	surface and subsurface layers is quite homogeneous.
Caruso[39]	*2-AISI 52100 steel, diameter 150mm, thickness 2.5mm, feed rate kept constant.*4-Microstructural changes deeply affect the residual stresses distribution and for this reason they have to be accurately taken into account during the process design.	------
V. Garcia Navas [40]	*2-AISI 4340 steel, *3-cutting speed, feed, tool nose radius geometry of tool chip breakers and coating of the cutting tool. *4-An increase in tool nose radius implies higher tool/ workpiece contact area, that result in higher temperature due to friction and less plastic deformation, leading to tensile residual stresses.	-------
Maranhao [41]	*1-Turning, *2-AISI 316 steel, FEM analysis, cutting speed, chip thickness. *4-The influence of the process parameters on residual stresses is feed rate, nose radius, rake angle.	Residual stresses are mostly influenced by feed rate and nose radius.
***1: Process, *2: Workmaterial used, *3: Machining parameters tested,* 4: Findings.**		

There is no uniformity in conducting experimentation as regards to the type of machining processes and the variables selected. Though many machining parameters like cutting speed, feed, depth of cut, tool nose radius, coolant type, cutting force etc. are found to influence the fatigue life, they have been studied in isolation. Therefore, no clear relationship cab be established between cutting parameter responsible for developing residual stresses and further its effects on fatigue life. Hence the disparity in the findings are not unnatural.It can further be observed that no much experimental models are available in literature to establish relationship for influence of cutting parameters on residual stresses.

MEASUREMENT TECHNIQUES

The literature indicates that the residual stresses are measured using either by non-destructive testing or by destructive method. X-Ray diffraction techniques are used for non-destructive testing. However, the output is measured in different from which is then converted in residual stress.

Thomas R. Watkinset.al. [3] on the basis of $\sin^2\psi$ plot suggested the possibility of the presence of both residual stress and composition gradients as a function of depth, given the nature of the steel nitriding process. The amount of nitrogen as a function of depth is determined using an electron microprobe. Laplace transform function is used to convert the microprobe data to an exponentially weighted volume average as sampled with X-ray diffraction. **A. T. Fry and J. D. Lord** [32] the proposed measurement of residual stresses by X-ray Diffraction to examine various aspects of the XRD test procedure. **Danial Magda**, [24] studied two methods for measuring residual stresses. First is the mechanical relaxation dissection method (destructive testing) which is very time consuming and inherently destructive. This method utilizes strain gauges to measure the strain relaxation after the part is sectioned away from the main body. Second method depends that is the techniques of residual stress measurement by X-ray diffraction. Where spacing of the atomic (hkl) planes in a metal material is altered by stress which can be determined by measuring the angular position of a position of a diffracted X-ray beam. **G. A. Webster and A. N. Ezeilo,** [5] studied the neutron diffraction non-destructive technique has been described. **P. J. Withers and H. K. D. H. Bhadeshia,** [6] studied that, residual stresses are difficult to predict than the in-service stresses on which they superimpose.

It can be seen that X-ray diffraction technique is more suitable and it has advantage over mechanical methods owing to the destructive part.Further microstresses cannot be measured by mechanical methods.

RESISUAL STRESS IN OTHER PROCESSES

The literature also available for measurement of residual stresses and its effect on fatigue for other machining processes. **M. Suraratchai** [22**]** et.al. and **Zhongyi** et.al.[37] have studied milling process. **A. Kortabarria**et.al. [38] has studied for drilling process. The study on grinding process has been presented by **Masayuki** et.al. [36] and **Yuuji Shimatani**et al, [35] and **B. A. Show** et.al. [8]. **Rahman Seifi** [23]**, G. Pouget** and **A. P. Reynolds** [20] and **M. N. James** et. al. [19] have studied welding process. **Diana A. Lados** et. al.[17] studied the casting process. **G. A. Webster** and **A. N. Ezeilo** [5] studied forging process.**J.J.Williams**et.al.[16] studied in cold pressing and sintering process. **Dongtao Jiang** et.al,[13] studied EDM process.

CONCLUSIONS

The literature reveals that:

Though residual stresses play significant role in fatigue life of mechanical components, the study so far dose not establish the causes and processes how to control the development of fatigue life. .

It also seen that compressive residual stresses are conducive while tensile residual stresses affect the fatigue life adversely further it different investigators have considered different parameters while performing experimentation.

The certainty of type of residual stresses beneath the machined surfaces and the corresponding depth is not yet known. It can be said that the type of residual stresses on the machined surfaces and beneath depends on the machining parameters used. However, it is not yet established mathematically or experimentally.

As the mathematical models do not reveal the machining parameters so as to estimate the type and amount of residual stresses developed on machining the component, they are having useful for practical processes.

Therefore, a fresh attempt is necessary to establish the relationship between cutting parameters in machining processes and the corresponding residual stresses developed. Such attempts are expected to help in improving fatigue life of machined components.

REFERENCES

1. A reference book on [1996] “Fatigue Design Technology and Engineering- Life Expectancy of Machine parts” by EliahuZahavi and Vladimir Torbilo, CRC Press.
2. A reference book on [1997] “Mechanics of Material 2: The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials” 3rd Edition by E J Hearn, Antony Rowe Ltd. Eastborne (Great Britain) ISBN 0 7506 3266 6.
3. Thomas R. Watkins and et.al, [2000] “ Measurement and Analysis of Residual stress in ε- phase Iron Niitride Layers as a function of Depth”, International Centre for Diffraction Data, Advance in X-ray Analysis, Vol.43.
4. T. D. Marusich and E. Askari [2001] a, “Modeling Residual Stress and Work piece Quality in Machined Surfaces”, Workshop Modeling of machining, pp. 1-5.
5. G. A Webster, A. N Ezeilo [2001] b, “Residual stress distributions and their influence on fatigue lifetimes”, International Journal of Fatigue 23, pp. 375-383.
6. P. J. Withers and H. K. D. H. Bhadeshia [April 2001] c, “Overview Residual stress Part 1- Measurement techniques”, Material Science and Technology, Vol.17.
7. M. H. El-Axir, [2002], “A method of modeling Residual Stresses distribution in turning for different materials”, International Journal of Machine Tool & Manufacture, 42, pp. 1055-1063.
8. B.A. Shaw, et. al. [2003], “The role of residual stress on the fatigue strength of high performance gearing”, International Journal of Fatigue 25, pp. 1279-1283.
9. Meng Liu, et.al.[2004]a , ”Effect of tool nose radius and tool wear on residual stress distribution in hard turning of bearing steel”, Journal of Material Processing Technology 150, 234-241.
10. Y.B. Guo and David W. Yen [2004] b, “Hard turning verses grinding- the effects of process-induced residual stresses on rolling contact”, Wear, 256, 393-399.
11. Meng Liu, and et al, [2004] c, “Effects of the nose radius and tool wear on residual stress distribution in hard turning on bearing steel, Journal of Materials Processing Technology 150, 234-241.
12. Hiroyuki Sasahara, [2005] a, “The effect on fatigue life of residual stresses and surface hardness resulting from different cutting conditions of 0.45%C steel, International journal of Machine Tool and Manufacturing 45, 131-136.
13. Dongtao Jiang, and et al, [2005] b, “Residual stresses in hard metals caused by grinding and EDM machining and their influence on the flexural strength”, 16th International Plansee Seminar on Powder Metallurgical High Performance Materials (Austria), Volume 2, pp. 1075-1085.

14. Edoardo Capello, [2005] c, “Residual stresses in turning Part I : Influence of process parameters”, Journal of Material Processing Technology 160, 221-228.

15. Edoardo Capello, [2006], “Residual stresses in turning Part II : Influence of process parameters”, Journal of Material Processing Technology 172, 319-326.

16. J.J. Williams, et. al. [2007] a, “Effect of Residual Stresses on the fatigue behavior of low–allay powder metallurgy steel”, International Journal of Fatigue 29, pp.1978-1984.

17. Daina A. Lados, and et al. [2007] b, “Fracture mechanics analysis for residual stress and crack closure corrections”, International Journal of Fatigue 29, pp. 687-694.

18. G. F. Batalha, and et. al. [2007] c,” Residual stresses modeling in hard turning and its correlation with the cutting forces”, Journal of Achievements in Materials and Manufacturing Engineering, Volume 24 Issue 1.

19. M. N. James and et.al. [2007] d, “Residual stresses and fatigue performance”,Engineering Failure Analysis14(2007)384-395.

20. G. Pouget, A. P. Reynolds, [2008] a, “Residual stress and microstructure effects on fatigue crack growth in AA2050 friction stir welds”, International Journal of Fatigue 30, pp. 463-472.

21. Ataollah Javidi, and et.al. [2008] b, “The effects of machining on the surface integrity and fatigue life”, International Journal of Fatigue 30, pp. 2050-2055.

22. M. Surahatchai, and et.al. [2008] c, “Modeling the influence of machined Surfaceroughness on the F.C. of aluminium alloy”, International Journal of Fatigue 30, pp. 2119-2126.

23. Rahman Seifi, [2008] d, “Effects of Residual stress & micro structure effects on fatigue crack Growth in AA 2050 friction stir welds”, International Journal of Fatigue 30, pp. 1895-1900.

24. Daniel Magda, [2008] e “AC 2008-900: Understanding the Effect of Residual stresses on Surface Integrity and How to Measure them by a Non-Destructive Method”, Weber State University, American Society for Engineering Education.

25. J.C. Outeiro and et.al. [2008] f, “Analysis of residual stresses induced by dry turning of difficult-to-machine materials”, CIRP Annals-Manufacturing Technology 57, 77-80.

26. Y. B. Guo and A.W. Warren, [2009] a “The Basic Relationship Between Residual Stresses Profile Patterns and Fatigue Life of Precision Machined Surfaces in Rolling Contact”, International Centre for Diffraction Data, ISSN 1097-0002, pp. 336-343.

27. Youngsik Choi, [2009] b “A study on the effects on the machining- induced residual stress on rolling contact fatigue”,Journal of Fatigue 31, pp. 1517-1523.

28. Tadeusz Leppert, [2009] c”Surface Residual Stresses in Dry Turning of 0.45% C Steel”, International Centre for Diffraction Data, ISSN 1097-0002.

29. G. H. Farrahi and et.al. [2009] d, “A New Analytical Approach to Reconstruct Residual Stresses Due to Turning Process”, World Academy of science, Engineering and Technology 55, pp. 453-457.

30. Tadeusz Leppert and Ru Lin Peng, [2009] e, “ Surface Residual Stresses in dry Turning of 0.45% C Steel”, International Centre for Diffraction Data, ISSN 1097-0002.
31. Y.B.Guo, and et.al, [2009] f,” A novel hybrid predictive model and validation of unique hook-shaped residual stress profiles in hard turning.” CIRP Annals-Manufacturing Technology 58, 81-84.
32. A. T. Fry and J.D.Lord, [2009] g, “Measuring Residual stresses in Stainless Steel- Recent Experiences Within A Vamas Exercise”, International Centre for Diffraction Data, ISSN 1097-0002.
33. M. Smaga, and D. Eifler, [2010] a, “Effect of residual stress and on the fatigue behavior of aluminium matrix composites”,Int. conference on the strength of materials (ICSMA-15), pp. 1-4.
34. S. Anurag and et.al., [2010] b, “A New FEM Approach to Predict Residual Stress Profiles In Hard Turning Without Simulation Chip Formation”, Transactions of NAMRI/SME, Volume 38.
35. Yuuji Shimatani and Kazauki Shiozauoa, [2011] a, “The effects of the residual stresses generated by surface finishmethods on the VHCL behavior of matrix HSS”, International Journal of Fatigue 36, pp. 122-131.
36. Masayuki Tai and et.al. [2011] b, “Mechanism of Fatigue Strength Improvement by Applying Peening Treatment”, Twelfth East Asia-Pacific Conference on Structural Engineering and Construction, Procedia Engineering, 14, pp. 117-125.
37. Mei Zhongyi, and et. al [2011] c., “Distortion Analysis of Shaped Workpiece in NC Machining”, Proceedings of World Congress on Engineering 2011, vol. III, London, UK, on line.
38. A. Kortabarria and et. al [2011] d., “A comparative study of residual stress profile on Inconel718 induced by dry face turning. Procedia Engineering 19, 228-234.
39. S. Caruso, and et. al, [2011] e” An experimental investigation of residual stresses in hard machining of AISI 52100 steel”, Procedia Engineering 19, 67-72.
40. Virginia Garcia Naas and et al, [2012] a ”Effects of cutting parameters in the surface residual stresses generated by turning in AISI 4340 steel, International journal of Machine Tool and Manufacturing 61,48-57.
41. C. Maranhao and J. P. Davim, [2012] b “Residual stresses in Machining Using FEM Analysis-A Review”, Rev.Adv.Mater Sci. 30, 267-272.